AF\2643/1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Pawel S. Sleboda, et al.

Serial No.: 10/049,993

Filed: April 2, 2002

Group Art Unit: 2643

Examiner: Lao, Lun S.

For: VEHICULAR AUDIO SYSTEM INCLUDING A HEADLINER SPEAKER, ELECTROMAGNETIC TRANSDUCER ASSEMBLY FOR USE THEREIN AND COMPUTER SYSTEM PROGRAMMED WITH A GRAPHIC SOFTWARE CONTROL FOR CHANGING THE AUDIO SYSTEM'S SIGNAL LEVEL AND DELAY

Attorney Docket No.: LDOS0230PUSA

SUPPLEMENTAL APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
U.S. Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is a supplemental appeal brief from the rejection of claims 1-11, 13-23, and 25-45 of the Office Action dated July 14, 2004. This appeal brief replaces the appeal brief filed on April 21, 2004 in response to the final rejection of claims 1-45 of the Office Action dated December 1, 2003. This application was filed on April 2, 2002.

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I hereby certify that this paper, including all enclosures referred to herein, is being deposited with the United States Postal Service as first-class mail, postage pre-paid, in an envelope addressed to: Mail Stop Appeal Brief - Patents, Commissioner for Patents, U.S. Patent & Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450 on:

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existing under the laws of the state of Delaware, and having a place of business at 21557 Telegraph Road, Southfield, Michigan 48034, as set forth in the assignment recorded in the U.S. Patent and Trademark Office on April 2, 2002 at Reel 012956/Frame 0435.

II. RELATED APPEALS AND INTERFERENCES

Concurrent with the present appeal, an appeal has been filed to U.S. application no. 09/382,851, filed August 25, 1999 and titled "VEHICULAR AUDIO SYSTEM AND ELECTROMAGNETIC TRANSDUCER ASSEMBLY FOR USE THEREIN" of which the present application is a continuation-in-part, and which is under final rejection issued by the same Examiner as the present application.

III. STATUS OF CLAIMS

Claims 1-61 are pending in this application. Claims 1-45 are provisionally rejected under the judicially created doctrine of double patenting over claims 1-41 and 43-44 of co-pending U.S. application no. 09/382,851. Claims 46-61 have been withdrawn in response to a restriction requirement issued March 31, 2003. Claims 12 and 24 are objected to as being dependent upon a rejected base claim but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claims 1-11, 13-23, and 25-45 have been rejected as being unpatentable under 35 U.S.C. § 103(a) and are the subject of this appeal.

IV. STATUS OF AMENDMENTS

An amendment including a Terminal Disclaimer to U.S. application no. 09/382,851 in response to the non-final rejection dated July 14, 2004 is filed herewith. There are no amendments to the claims pending in the present application.

V. SUMMARY OF THE INVENTION

The present invention provides an audio system for use in a vehicle (16) having a roof. The system comprises a headliner (11), a source of audio signals (15), an array of electromagnetic transducer assemblies (12), and signal processing circuitry (17). The headliner may be adapted to be mounted adjacent the roof so as to underlie the roof and shield the roof from view. The headliner has an upper surface and a sound-radiating, lower surface. The array of electromagnetic transducer assemblies may be supported at the upper surface of the headliner. The signal processing circuitry may be coupled to the assemblies for processing the audio signals to obtain processed audio signals. The assemblies may convert the processed audio signals into mechanical motion of corresponding zones of the headliner. The headliner is generally made of a material which is sufficiently stiff and low in density so that the headliner radiates acoustic power into the interior of the vehicle as a single speaker with a frequency range defined by a lower limit of 100 hertz or less and an upper limit of 12 kilohertz or more and the processed audio signals at a low end of the frequency range are matched to the processed audio signals at mid and high ends of the frequency range. (See, for example, Figures 1 and 2, and the specification on page 5, ll. 13-27, and page 15, l. 24 through page 17, l. 5).

VI. ISSUES

1. Claims 1, 9-11, 13, 15, 16, 35-38, 40, 41 and 45 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,356,641 to Warnaka, et al. (hereinafter Warnaka) in view of U.S. Patent No. 5,754,664 to Clark, et al. (hereinafter Clark). The first issue is whether the Examiner has made a *prima facie* case that claims 1, 9-11, 13, 15, 16, 35-38, 40, 41 and 45 are unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark.

2. Claims 2-4, 14, 17 and 43 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Warnaka in view of Clark, and further in view of U.S. Patent No.

5,887,071 to House (hereinafter House). The second issue is whether the Examiner has made a *prima facie* case that claims 2-4, 14, 17 and 43 are unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark, and further in view of House.

3. Claims 5-8 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Warnaka in view of Clark, and further in view of U.S. Patent No. 4,385,210 to Marquiss (hereinafter Marquiss). The third issue is whether the Examiner has made a *prima facie* case that claims 5-8 are unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark, and further in view of Marquiss.

4. Claims 18-23 and 25-34 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Warnaka in view of Clark, and further in view of international application WO99/11490 to Azima (hereinafter Azima WO '490). The fourth issue is whether the Examiner has made a *prima facie* case that claims 18-23 and 25-34 are unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark, and further in view of Azima WO '490.

5. Claim 39 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Warnaka in view of Clark, and further in view of U.S. Patent No. 5,450,057 to Watanabe (hereinafter Watanabe). The fifth issue is whether the Examiner has made a *prima facie* case that claim 39 is unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark, and further in view of Watanabe.

6. Claims 42 and 44 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Warnaka in view of Clark, and further in view of U.S. Patent No. 6,332,029 to Azima (hereinafter Azima '029). The sixth issue is whether the Examiner has made a *prima facie* case that claims 12, 24, 43 and 44 are unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark, and further in view of Azima '029.

VII. GROUPING OF CLAIMS

Applicants contend that claims 1-11, 13-23 and 25-45 stand or fall together.

VIII. ARGUMENT

1. The Examiner has Failed to Make a Prima Facie Case that Claims 1-11, 13-23 and 25-45 are Unpatentable under 35 U.S.C. §103(a)

A *prima facie* case of obviousness requires three basic criteria:

> First, there must be some suggestion of motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.
>
> The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure.
>
> (*In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)).

Furthermore, "[a] prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention." (*W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984)).

Here, the Examiner has rejected claim 1 as being unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark. The Examiner has failed to establish, however, that the combination of Warnaka and Clark teach or suggest all the limitations of the Applicants' claimed invention. In particular, independent claim 1 provides an acoustically-insulating headliner adapted to be mounted adjacent a roof, the headliner having an upper surface and a sound-radiating, lower surface, an array of electromagnetic transducer assemblies supported at the upper surface of the headliner, wherein the assemblies convert processed audio signals

into mechanical motion of corresponding zones of the headliner, and the headliner is made of a material which is sufficiently stiff and low in density so that the headliner radiates acoustic power into the interior of the vehicle as a single speaker.

The Examiner contends that Warnaka teaches an array of piezoelectric transducers obvious to substitute by electromagnetic transducers. (See, Office Action dated July 14, 2004 at page 5, ll. 7-8). However, the Examiner has mis-characterized Warnaka. In particular, Warnaka teaches transducers (15), which are flat piezoelectric elements. (Warnaka, col. 5, ll. 16-19). One of ordinary skill in the art would understand that piezoelectric elements may be defined as transducers that depend for their operation on the interaction between the electric charge and the deformation of certain assymetric crystals having piezoelectric properties. (See, for example, Graf, Rudolf, Modern Dictionary of Electronics, 1997, page 748, a copy of which is attached for the Examiner's convenience). Warnaka discusses the deficiencies of other types of transducers *vis a vis* piezoelectric transducers (Warnaka, col. 11, ll. 15-28) but nowhere does Warnaka provide disclosure of an enabled alternative embodiment of an invention that implements electromagnetic transducers. As such, Warnaka fails to teach an array of electromagnetic transducers as presently claimed.

In contrast, claim 1 provides for an array of electromagnetic transducers. In any case, nowhere does Waraka teach, disclose or suggest an array of electromagnetic transducer assemblies where the assemblies convert processed audio signals into mechanical motion of corresponding zones of the headliner, and the headliner is made of a material which is sufficiently stiff and low in density so that the headliner radiates acoustic power into the interior of the vehicle as a single speaker with a frequency range defined by a lower limit of 100 hertz or less and an upper limit of 12 kilohertz.

Furthermore, the use of piezoelectric elements for driving portions of interior trim was well known and fully considered by the Applicants. (See, Background of the present

application, page 3, ll. 10-19. Note also, the inventor, Parrella, of the reference discussed in the Background, i.e., U.S. Patent No. 5,901,231, is a co-inventor of the Warnaka reference). As discussed in the Background of the present application, the use of piezo-electric elements restricts them to dividing up the trim into different sections for different frequency ranges adding complexity to the system. Furthermore, the excursion limits of piezo elements limits the output level and low frequency range of the trim panels such that conventional cone speakers would be required to produce lower frequencies. The piezo elements also require complicated integration into the trim element and are difficult to service. Lastly, the piezo elements require additional circuitry to convert typical output from an automotive head unit further complicating the system. The present invention overcomes the deficiencies of the use piezoelectric elements for driving portions of interior trim as taught by Warnaka.

Clark was well known and fully considered by the Applicants. (See, specification on page 1, l. 27 through page 2, l. 14). The Examiner notes that Clark teaches a frequency range defined by a lower limit of 100 Hertz or less and an upper limit of 12 kiloHertz or more. (See, Office Action dated July 14, 2004 at page 6, ll. 1-4). The Examiner also contends that Clark teaches electromagnetic transducers. (See, Office Action dated July 14, 2004 at page 6, l. 9 through page 7, l. 3). However, the Examiner has mis-characterized Clark. Clark teaches overhead speakers that are positioned such that they provide strong front staging and desired ambience, and that are mounted directly to a headliner. (Clark, Abstract). Nowhere does Clark disclose, teach or suggest a headliner that radiates acoustic power into the interior of a vehicle as presently claimed.

One of ordinary skill in the art would understand that a loudspeaker as taught by Clark, in contrast to the electromagnetic transducers as defined in the present invention, can be defined as a transducer that reproduces sound by responding to an electrical signal produced by an amplifier. It contains a thin but rigid cone fixed to a coil. The electrical signal goes to the coil, which sits inside a magnetic field created by a circular permanent magnet around the

coil. The coil also produces its own magnetic field, which varies in strength as the varying signal passes through it. The two magnetic fields push and pull on each other, causing the coil to vibrate in step with the variations of the signal. The cone vibrates at the same frequencies as the original sound waves. (See, for example, Macaulay, David, The New Way Things Work, 1998, page 228, a copy of which is provided for the Examiner's convenience to illustrate the difference between electromagnetic transducers that convert audio signals into mechanical motion of corresponding zones of a headliner, as claimed, and loudspeakers as taught by Clark). As such, Clark fails to cure the deficiencies of Warnaka. Therefore, Warnaka and Clark, alone or in combination, fail to provide the claimed features of the present invention and the rejection should be withdrawn.

Furthermore, nowhere do Warnaka or Clark, alone or in combination, disclose, teach or suggest signal processing circuitry that is coupled to electromagnetic transducer assemblies for processing the audio signals to obtain processed audio signals where the assemblies convert the processed audio signals into mechanical motion of corresponding zones of the headliner, and the headliner is made of a material which is sufficiently stiff and low in density so that the headliner radiates acoustic power into the interior of the vehicle with a frequency range defined by a lower limit of 100 hertz or less and an upper limit of 12 kilohertz or more. The Examiner contends that Clark teaches a system of processed audio signals to be delivered to each electromagnetic transducer assembly (sic, speaker)...and utilizing mechanical mixing of the headliner to move the headliner between the left and right electromagnetic transducer assemblies (sic, speakers). (See, Office Action dated July 14, 2004 at page 7, ll. 11-21).

However, the Examiner has mis-characterized Clark. In particular, Clark teaches a control circuit (16) that generates output signals driving speakers (18-29). (Clark, Figs. 1, 3, 4 and 9, and col. 3, ll. 56 through col. 4, l. 44). Nowhere does Clark teach utilizing mechanical mixing of the headliner to move the headliner between the left and right

electromagnetic transducer assemblies as the Examiner contends. Clark does, in fact, teach, "The output of amplifier 164 is connected to speakers 22 such that a sum of the LP and RR signals is input to speaker 22 to present a center stage in the center of the vehicle for passengers in the rear seat." (Clark, col. 8, ll. 39-43).

Nowhere does Clark teach signal processing circuitry that is coupled to electromagnetic transducer assemblies for processing the audio signals to obtain processed audio signals where the assemblies convert the processed audio signals into mechanical motion of corresponding zones of the headliner. Clark, contrary to the Examiner's contention, further teaches, "[T]he space between the headliner and the bracket provides an uninterrupted air volume, and approaches a purely resistive termination, such that the space between the headliner and roof provides frictional surfaces which progressively dissipate sound propagating radially outwardly from each of the speakers mounted to the headliner. This unbaffled air volume thus effects pure, high quality sound reproduction from the speakers mounted in the vehicle headliner." (Clark, col. 6, ll. 41-49). As such, Clark fails to cure the deficiencies of Warnaka, Warnaka and Clark, alone or in combination, fail to provide all of the features of the presently pending invention, and the rejection should be reversed.

Yet furthermore, even if the cited references, alone or in combination, resulted in the presently pending invention which Applicants do not concede is the present case, the Examiner has failed to provide the motivation to combine the teaching of Warnaka and Clark as is required for a *prima facie* case of obviousness under 35 U.S.C. § 103(a). The mere fact that references can be combined or modified, which Applicants do not agree is the case with respect to the cited references, does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination or modification. In that regard, "[a] prior art reference must be considered in its entirety, i.e., as a <u>whole</u>, including portions that would lead away from the claimed invention". (*W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984)).

"The totality of the prior art must be considered, and proceeding contrary to accepted wisdom in the art is evidence of nonobviousness". (*In re Hedges*, 783 F.2d 1038, 228 USPQ 685 (Fed. Cir. 1986)).

"Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge generally available to one of ordinary skill in the art. 'The test for an implicit showing is what the combined teachings, knowledge of one of ordinary skill in the art, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art.'" (*In re Kotzab*, 217 F.3d 1365, 1370, 55 USPQ2d 1313, 1317 (Fed. Cir. 2000)).

The headliner taught by Warnaka is implemented with piezoelectric transducers. Clark teaches implementation of conventional loudspeakers mounted to the headliner. As such, Warnaka and Clark, alone or in combination, fail to provide any suggestion or motivation for the presently claimed invention and the rejection should be reversed.

The Examiner has also used impermissible hindsight to combine the teachings of Warnaka and Clark to attempt to piece together the Applicants' invention. The teaching or suggestion to make the claimed combination must be found in the prior art, not in the applicant's disclosure. (*In re Dembiczak*, 175 F.3d 994, 999, 50 USPQ2d 1614, 1617 (Fed. Cir. 1999) ("Combining prior art references without evidence of ... suggestion, teaching, or motivation simply takes the inventor's disclosure as a blueprint for piecing together the prior art to defeat patentability–the essence of hindsight.")). The Examiner has failed to provide any motivation for any combination of art that would provide the features of the present invention. In fact, both Warnaka and Clark fail to teach the implementation of electromagnetic transducer assemblies, and a headline that is made of a material which is sufficiently stiff and low in

density so that the headliner radiates acoustic power into the interior of the vehicle as a single speaker, as presently claimed.

Moreover, "[d]efining the problem in terms of its solution reveals improper hindsight in the selection of the prior art relevant to obviousness." (*Ecolochem, Inc. v. Southern Edison Co.*, 227 F.3d 1361, 1372, 56 USPQ2d 1065, 1073 (Fed. Cir. 2000) (citing *Monarch Knitting Mach. Corp. v. Sulzer Morat Gmbh*, 139 F.3d 877, 880, 45 USPQ2d 1977, 1981 (Fed. Cir. 1998)). Here, the references cited by the Examiner fails to recognize the problem addressed by the Applicants' claimed invention (i.e., as stated in the presently pending application on page 4, ll. 19-26, "There is still a need to reduce parts and labor cost, decrease weight, decrease exterior noise penetration, provide believable imaging, reduce speaker visibility, increase reliability, and provide easy serviceability...using existing trim panel space and mounting techniques, conventional audio signal head unit output, advanced material properties manipulation and well established signal processing, and psychoacoustic techniques."). Warnaka concerns a headliner excited by transducers that are flat piezoelectric elements. Clark is directed to a vehicle audio system that includes overhead speakers that are direct driving speakers. As such, Warnaka and Clark, alone or in combination, fail to teach the invention as presently claimed. As such, the Examiner has failed to make a *prima facie* case of obviousness as is required under 35 U.S.C. § 103 and the rejection should be reversed.

Regarding the claims which depend from claim 1, Applicants contend that these claims are patentable for at least the same reasons that claim 1 is patentable. Moreover, Applicants contend that these claims recite further limitations, in addition to the limitations of claim 1, which render these claims additionally patentable. In particular, claim 5 provides the limitations of claim 1 and further provides each of the electromagnetic transducer assemblies includes a magnet for establishing a magnetic field in a gap formed within the assembly, a coil which moves relative to the magnet in response to the processed audio signals, a base fixedly secured to the headliner on the upper surface and electrically connected to the signal processing

circuitry and a guide member electrically connected to the coil and removably secured to the base for supporting the coil in the gap and wherein the coils are electrically coupled to the signal processing circuit when the guide members are secured to their corresponding bases.

The Examiner has rejected claim 5 as being unpatentable under 35 U.S.C. § 103(a) over Warnaka in view of Clark and further in view of Marquiss. However, Marquiss teaches an electro-acoustic transducer using a segmented planar diaphragm. (Marquiss, col. 2, l. 56 through col. 3, l. 0). Marquiss fails to disclose, teach or suggest electromagnetic transducer assemblies that convert the processed audio signals into mechanical motion of corresponding zones of the headliner, and the headliner is made of a material which is sufficiently stiff and low in density so that the headliner radiates acoustic power into the interior of the vehicle with a frequency range defined by a lower limit of 100 hertz or less and an upper limit of 12 kilohertz or more, as presently claimed. As such, Marquiss fails to cure the deficiencies of Warnaka and Clark and the rejection should be reversed.

IX. CONCLUSION

The Examiner rejected as being unpatentable under 35 U.S.C. § 103(a) claims 1, 9-11, 13, 15, 16, 35-38, 40, 41 and 45 over Warnaka in view of Clark, claims 2-4, 14, 17 and 43 over Warnaka in view of Clark, and further in view of House, claims 5-8 over Warnaka in view of Clark, and further in view of Marquiss, claims 18-23 and 25-34 over Warnaka in view of Clark, and further in view of Azima WO '490, claim 39 over Warnaka in view of Clark, and further in view of Watanabe, and claims 43 and 44 over Warnaka in view of Clark, and further in view of Azima '029. However, the Examiner has failed to establish a *prima facie* case of obviousness under 35 U.S.C. §103(a). In particular, the references cited by the Examiner, alone or in combination, fail to teach or suggest all the elements of the presently pending independent claim 1.

Dependent claims 2-11, 13-23, and 25-45 are patentable for at least the same reasons that claim 1 is patentable. In addition, the Examiner has failed to show a proper suggestion or motivation for combining the references. Therefore, the rejection of the presently pending claims 1-11, 13-23, and 25-45 should be reversed.

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Respectfully submitted,

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Enclosure - Appendix, Claims on Appeal
Graf, Rudolf, Modern Dictionary of Electronics, 1997, page 748
Macaulay, David, The New Way Things Work, 1998, page 228

IX. APPENDIX - CLAIMS ON APPEAL

1. An audio system for use in a vehicle having a roof, the system comprising:

a headliner adapted to be mounted adjacent the roof so as to underlie the roof and shield the roof from view, the headliner having an upper surface and a sound-radiating, lower surface;

a source of audio signals;

an array of electromagnetic transducer assemblies supported at the upper surface of the headliner;

signal processing circuitry coupled to the assemblies for processing the audio signals to obtain processed audio signals wherein the assemblies convert the processed audio signals into mechanical motion of corresponding zones of the headliner and wherein the headliner is made of a material which is sufficiently stiff and low in density so that the headliner radiates acoustic power into the interior of the vehicle as a single speaker with a frequency range defined by a lower limit of 100 hertz or less and an upper limit of 12 kilohertz or more and the processed audio signals at a low end of the frequency range are matched to the processed audio signals at mid and high ends of the frequency range.

2. The system as claimed in claim 1 wherein the vehicle has a windshield and wherein the array of electromagnetic transducer assemblies includes at least one row of electromagnetic transducer assemblies adjacent the windshield and wherein the at least one row of electromagnetic transducer assemblies are positioned 5 to 30 inches in front or an expected position or a passenger in the interior of the vehicle.

3. The system as claimed in claim 2 wherein the at least one row of electromagnetic transducer assemblies are positioned 12 to 24 inches in front of the expected position of the passenger.

4. The system as claimed in claim 2 wherein the at least one row of electromagnetic transducer assemblies includes at least two electromagnetic transducer assemblies spaced apart to correspond to left and right ears of the passenger in the expected position of the passenger.

5. The system as claimed in claim 1 wherein each of the electromagnetic transducer assemblies includes a magnet for establishing a magnetic field in a gap formed within the assembly, a coil which moves relative to the magnet in response to the processed audio signals, a base fixedly secured to the headliner on the upper surface and electrically connected to the signal processing circuitry and a guide member electrically connected to the coil and removably secured to the base for supporting the coil in the gap and wherein the coils are electrically coupled to the signal processing circuit when the guide members are secured to their corresponding bases.

6. The system as claimed in claim 5 wherein each of the magnets is a high-energy permanent magnet.

7. The system as claimed in claim 6 wherein each of the high-energy permanent magnets is a rare-earth magnet.

8. The system as claimed in claim 5 wherein each of the assemblies includes a spring element having a resonant frequency below the lower limit of the frequency range when incorporated within its assembly and connected to its corresponding guide member for resiliently supporting its corresponding magnet above the upper surface of the headliner.

9. The system as claimed in claim 1 wherein the array or electromagnetic transducer assemblies includes a front row of electromagnetic transducer assemblies positioned 5 to 30 inches in front of an expected position of a passenger in the interior of the vehicle and

a back row of electromagnetic transducer assemblies positioned behind the expected position of the passenger wherein the signal processing circuitry delays the audio signals coupled to the back row of electromagnetic transducer assemblies relative to the audio signals coupled to the front row of electromagnetic transducer assemblies.

10. The system as claimed in claim 1 wherein the array of electromagnetic transducer assemblies are completely supported on the upper surface of the headliner.

11. The system as claimed in claim 1 further comprising at least one loudspeaker coupled to the signal processing circuitry, and adapted to be placed in the interior of the vehicle in front of an expected position of a passenger and below the headliner.

12. The system as claimed in claim 1 wherein the headliner material has a flexural modulus between 1E7PA and 4E9PA and a density of between 100 and 800 kg/m^3.

13. The system as claimed in claim 1 wherein the electromagnetic transducer assemblies are spaced to the left and right, front and rear of expected positions of passengers in the interior of the vehicle to create proper audio imaging for the passengers.

14. The system as claimed in claim 1 further comprising at least one loudspeaker positioned in front of expected positions of passengers below the headliner but not in doors, kick panels, or under a dash of the vehicle.

15. The system as claimed in claim 1 further comprising a low frequency speaker positioned below the headliner in the interior of the vehicle.

16. The system as claimed in claim 1 wherein the array has front and rear assemblies and wherein each rear electromagnetic transducer assembly is coupled to processed

audio signals delayed in time relative to the processed audio signals coupled to each front electromagnetic transducer assembly.

17. The system as claimed in claim 1 wherein the audio signals are processed with head-related transfer functions by the signal processing circuitry.

18. The system as claimed in claim 1 wherein the electromagnetic transducer assemblies are supported only on the headliner.

19. The system as claimed in claim 1 wherein the headliner is self-supporting.

20. The system as claimed in claim 1 further comprising a semi-compliant attachment mechanism adapted to attach the headliner to the roof along at least a substantial periphery of the roof.

21. The system as claimed in claim 1 further comprising a semi-compliant attachment mechanism adapted to attach the headliner to the roof along at least a substantial periphery of the roof and a central portion of the roof.

22. The system as claimed in claim 1 further comprising a support structure for reinforcing the headliner.

23. The system as claimed in claim 1 further comprising framing independent of the headliner to support the assemblies.

24. The system as claimed in claim 1 wherein the headliner material has a flexural modulus between 1E7PA and 4E9PA and a density between 100 and 800 kg/m^3 and wherein the headliner material may be made from a single material or composites.

25. The system as claimed in claim 1 wherein stiffness and density of the headliner material is altered around the entire periphery of the headliner to allow for additional excursion of the entire headliner in order to create better low frequency reproduction (<200 Hz) of the processed audio signals.

26. The system as claimed in claim 1 further comprising a fabric or other material adhered to the lower surface of the headliner to create a cosmetically acceptable appearance for the system.

27. The system as claimed in claim 1 further comprising a fabric or other material adhered to the upper surface of the headliner for routing wires over the headliner in order to keep the wires from vibrating when in contact with a vibrating headliner.

28. The system as claimed in claim 1 further comprising audio signal wires integrated into the headliner.

29. The system as claimed in claim 1 further comprising a material adhered to the headliner to provide additional mass or damping or stiffness thereby minimizing unwanted excess vibration caused by any resonances in the headliner material.

30. The system as claimed in claim 1 further comprising fiberglass or other suitable material positioned between the headliner and the roof to minimize undesirable acoustical reflections from the roof, to minimize standing waves set up in a cavity created

between the headliner and the roof and to prevent the array of electromagnetic transducer assemblies from engaging the roof.

31. The system as claimed in claim 1 wherein a electromagnetic transducer assembly for a local sound zone is located between 5" and 30" in front of an expected ear location for a passenger.

32. The system as claimed in claim 1 wherein at least one of the electromagnetic transducer assemblies is adhered directly to the headliner.

33. The system as claimed in claim 1 wherein each of the electromagnetic transducer assemblies includes a subassembly having vibrational characteristics and adapted to be screwed, snapped, or twisted into position at the upper surface of the headliner whereby vibrational characteristics of each of the subassemblies can be tested for performance and quality prior to its installation on the headliner.

34. The system as claimed in claim 33 wherein each of the assemblies includes a base fixedly secured to the headliner and a bayonet-style coupling for removably securing its corresponding subassembly to its base and wherein each coupling also makes electrical contact between a conductor which is coupled to the circuitry and its corresponding subassembly.

35. The system as claimed in claim 1 wherein the processed audio signals to be delivered to each electromagnetic transducer assembly may be routed to alternate electromagnetic transducer assemblies to achieve different imaging and performance goals, the processed audio signals being monaural, stereo, or multi-channel signals.

36. The system as claimed in claim 1 wherein an acoustical center channel signal in a multi-channel setup is achieved by sending a processed center channel signal to both left and the right channel electromagnetic transducer assemblies in a row of electromagnetic transducer assemblies and utilizing mechanical mixing of the headliner to move the headliner between the left and right channel electromagnetic transducer assemblies as a center channel speaker.

37. The system as claimed in claim 1 further comprising a compliant material positioned between the assemblies and the roof.

38. The system as claimed in claim 1 further comprising at least one microphone positioned in the interior of the vehicle for intra-cabin and extra-cabin communications.

39. The system as claimed in claim 1 wherein the processed audio signals represent global or local vehicle warnings delivered to the entire or local interior sections of the vehicle.

40. The system as claimed in claim 1 wherein the signal processing circuitry utilizes adaptive filtering techniques to perform automatic system equalization.

41. The system as claimed in claim 1 wherein each area in the interior of the vehicle can be separately equalized.

42. The system as claimed in claim 1 wherein the headliner has a relatively high coincidence frequency to maximize channel separation, provide accurate imaging and minimize distortion and wherein the coincidence frequency is greater than 12 KHz.

43. The system as claimed in claim 1 wherein the audio signals are processed with trans-aural techniques to widen or narrow an image.

44. The system as claimed in claim 1 wherein the headliner has a structure which is broken at a flexure to minimize transfer of mechanical motion across the flexure.

45. The system as claimed in claim 1 wherein the system has a frequency response shape wherein the signal processing circuitry changes the shape of an equalization curve applied to the audio signals based on the signal level of the audio signals to maintain the frequency response shape relatively constant as the signal level of the audio signals change.

46. (withdrawn) An electromagnetic transducer assembly comprising:

a subassembly including:

a housing;

a magnet for establishing a magnetic field within the housing;

a coil which moves relative to the magnet in response to an audio signal; and

a flexible spider and guide member for supporting the coil centrally within the magnetic field; and

a mating base for attaching the subassembly to a vehicle headliner wherein the subassembly is removably secured to the mating base by screwing, snapping or twisting.

47. (withdrawn) The assembly as claimed in claim 46 wherein the flexible spider includes a plurality of flexing legs circumferentially spaced about an outer periphery of the spider.

48. (withdrawn) The assembly as claimed in claim 47 wherein each of the flexing legs has a shape of a sinusoidal wave.

49. (withdrawn) The assembly as claimed in claim 47 wherein each of the flexing legs has a pair of end portions which taper to a relatively thin middle portion.

50. (withdrawn) The assembly as claimed in claim 49 wherein each of the flexing legs has at least one edge profile which follows a cosine function.

51. (withdrawn) The assembly as claimed in claim 46 further comprising a bayonet-style coupling for mechanically connecting the spider and guide member to the base and electrically connecting the coil to a cable which supplies the audio signal after rotation of the spider and guide member relative to the base under a biasing force.

52. (withdrawn) The assembly as claimed in claim 51 wherein the bayonet-style coupling includes an electrically conductive spring electrically connected to the coil and supported on the spider and guide member for supplying the biasing force and electrically connecting the coil to the cable.

53. (withdrawn) The assembly as claimed in claim 46 further comprising at least one electrically conductive member disposed between the flexible spider and guide member and the mating base for electrically coupling the coil to a flat flexible cable disposed between the spider and guide member and the mating base upon securing the subassembly to the mating base.

54. (withdrawn) The assembly as claimed in claim 53 wherein the at least one electrically conductive member includes a pair of spaced electrically conductive springs which urge the spider and guide member away from the mating base during securing of the subassembly to the mating base.

55. (withdrawn) The assembly as claimed in claim 46 wherein the spider and guide member form a single part.

56. (withdrawn) The assembly as claimed in claim 46 wherein the coil includes a notch for aligning the coil on the spider and guide member to insure proper polarity of the coil.

57. (withdrawn) The assembly as claimed in claim 46 wherein the spider and guide member has threads for securing the spider and guide member to the housing.

58. (withdrawn) The assembly as claimed in claim 57 further comprising an adhesive for adhesively securing the housing to the spider and guide member at the threads.

59. (withdrawn) The assembly as claimed in claim 46 wherein the spider and guide member includes a centering ledge portion for centering the housing on the spider and guide member.

60. (withdrawn) The assembly as claimed in claim 46 wherein the coil includes at least one conductive pin for coupling the coil to audio signals.

61. (withdrawn) A computer system for controlling a digital signal processor which processes an audio signal of an audio system, the computer system comprising:

a computer adapted to be coupled to the digital signal processor;

a display coupled to the computer for displaying a graph of signal delay versus signal gain of an audio signal to be manipulated by the digital signal processor; and

an input device coupled to the computer for generating an input signal, the computer being programmed with a graphic software control to modify the graph in response to the input signal wherein level and delay of the audio signal are changed simultaneously.

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opposite polarity on pairs of the crystal face. The charges are proportional to the pressure, and disappear when the pressure is removed.

piezoelectricity — The phenomenon whereby certain crystalline substances, such as barium titanate, generate electrical charges when subjected to mechanical deformation. The effect was first noticed by the Curie brothers in the 1880s as a result of extensive study of the symmetry of crystalline materials. The reverse effect also occurs.

piezoelectric loudspeaker —*See* Crystal Loudspeaker.

piezoelectric material — A material which generates an electrical output when subjected to a mechanical stress. (The word is derived from the Greek *piezein,* meaning to squeeze or press.)

piezoelectric microphone —*See* Crystal Microphone.

piezoelectric oscillator — A crystal-oscillator circuit in which the frequency is controlled by a quartz crystal. *Also see* Pierce Oscillator.

piezoelectric pickup — 1. A type of cartridge whose generating element is a ceramic, crystal, or electret which generates electricity when bent, twisted, or stressed. The output of such cartridges can be fairly high. It is also proportional to the amplitude of the stylus motion, rather than stylus velocity, and so requires no equalization. Both these factors allow the use of simpler input circuits, one reason why piezoelectric (chiefly ceramic) cartridges are used in low-cost equipment. 2. *See* Crystal Pickup.

piezoelectric pressure gage —An apparatus for measuring or recording very high pressures. The pressure is applied to quartz discs or other piezoelectric crystals. The resultant voltage, after amplification, is then measured or is recorded with an oscillograph.

piezoelectric speaker — *See* Crystal Speaker.

piezoelectric transducer — Also called ceramic or crystal transducer. A transducer that depends for its operation on the interaction between the electric charge and the deformation of certain asymmetric crystals having piezoelectric properties.

piezoelectric transduction — The conversion of the measurand into a change in the electrostatic charge or voltage generated by mechanically stressed crystals.

piezoid —The finished crystal product. It may include the electrodes making contact with the crystal blank.

piezo-optical transducer — A structure consisting of a thin film of liquid crystal sandwiched between light polarizing filters that have received a surface lubricant. Depending on the motion, the transducer acts as highly sensitive detector by virtue of the sensitivity of the liquid crystal that is made to float by the lubricant between the plates. It produces a readily visible and colorful optical pattern that is dependent on the amount of disturbance.

piezoresistance—Resistance that changes with pressure.

piezoresistive transduction — A change in the resistance of a conductor or semiconductor caused by a change in the mechanical stress applied to it.

pig discharge—*See* Penning discharge.

piggyback—*See* Voltage Corrector.

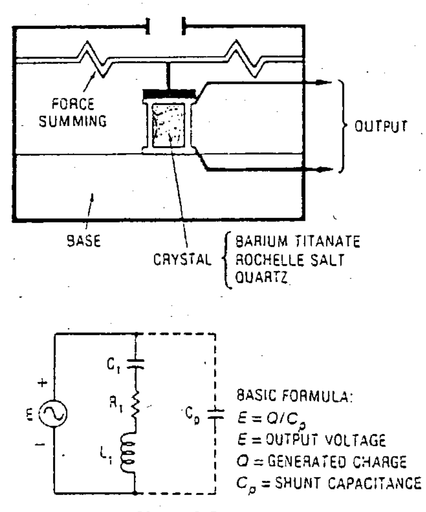
piggyback control—*See* Cascade Control.

piggyback twistor — An electrically alterable, nondestructive-readout information-storage device that consists of a thin, narrow tape of magnetic material wound spirally around a fine copper conductor. A second similar tape is wrapped on top of the first to sense the stored information. A binary digit is stored at the intersection of a copper strap and a pair of these twistor wires.

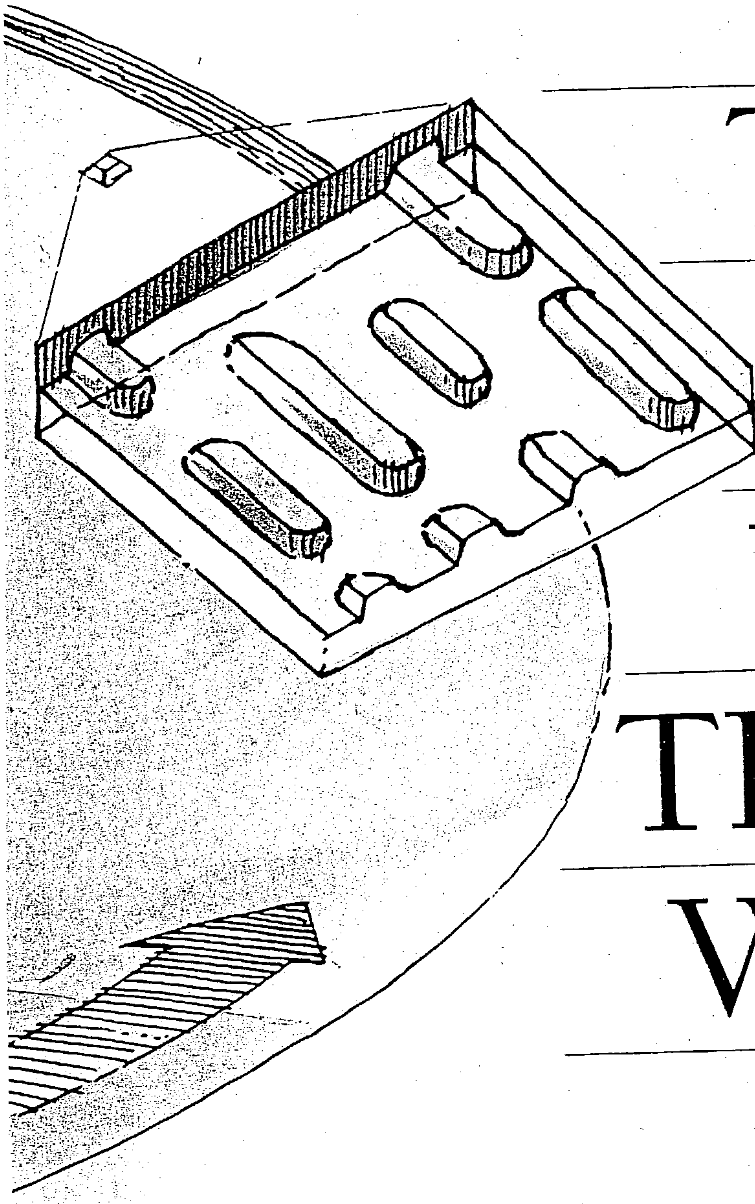
pigtail— 1. Either a wire attached for terminating purposes to a shield, or a conductor extending from a small component. 2. The termination of a capacitor winding to its lead. 3. The disc-shaped head, at the end of a lead, that is attached to a capacitor winding. 4. A short wire extending from an electric or electronic device to serve as a jumper or ground connection.

pigtail splice — A splice made by tightly twisting the bared ends of parallel conductors together.

pigtail wire — Fine-stranded, extra-



Piezoelectric transducer.



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DAVID MACAULAY

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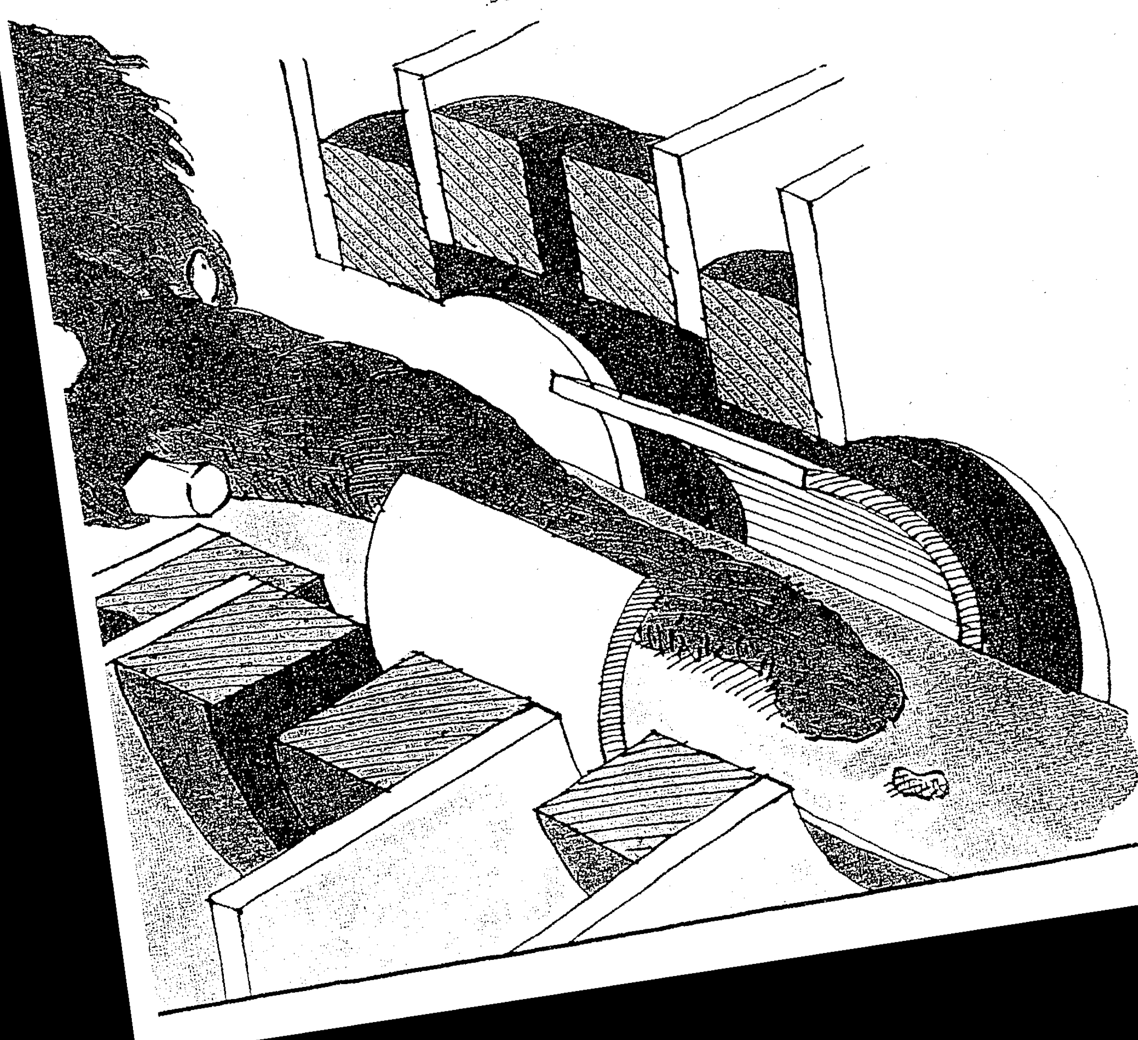
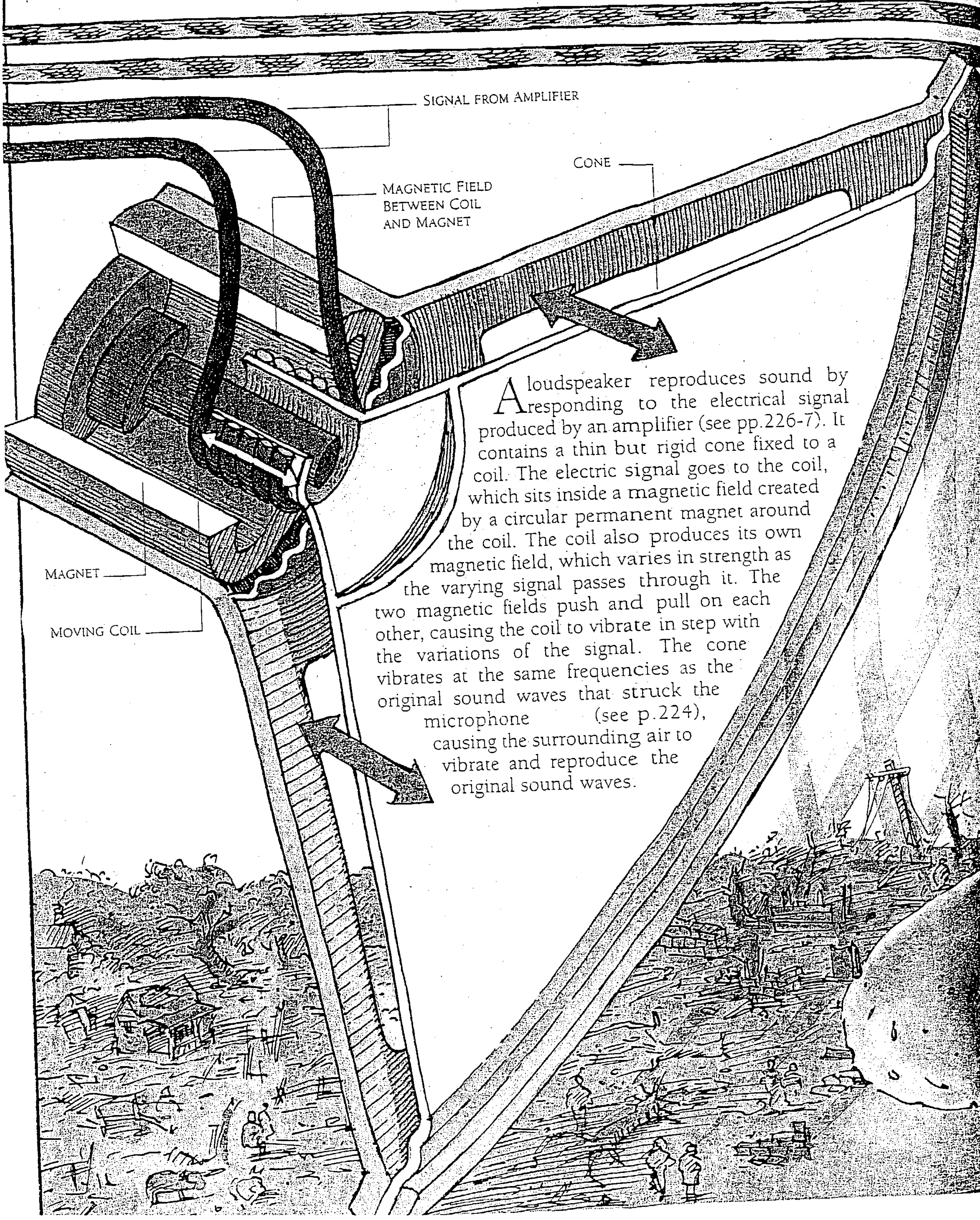


LOUDSPEAKER



A loudspeaker reproduces sound by responding to the electrical signal produced by an amplifier (see pp.226-7). It contains a thin but rigid cone fixed to a coil. The electric signal goes to the coil, which sits inside a magnetic field created by a circular permanent magnet around the coil. The coil also produces its own magnetic field, which varies in strength as the varying signal passes through it. The two magnetic fields push and pull on each other, causing the coil to vibrate in step with the variations of the signal. The cone vibrates at the same frequencies as the original sound waves that struck the microphone (see p.224), causing the surrounding air to vibrate and reproduce the original sound waves.